

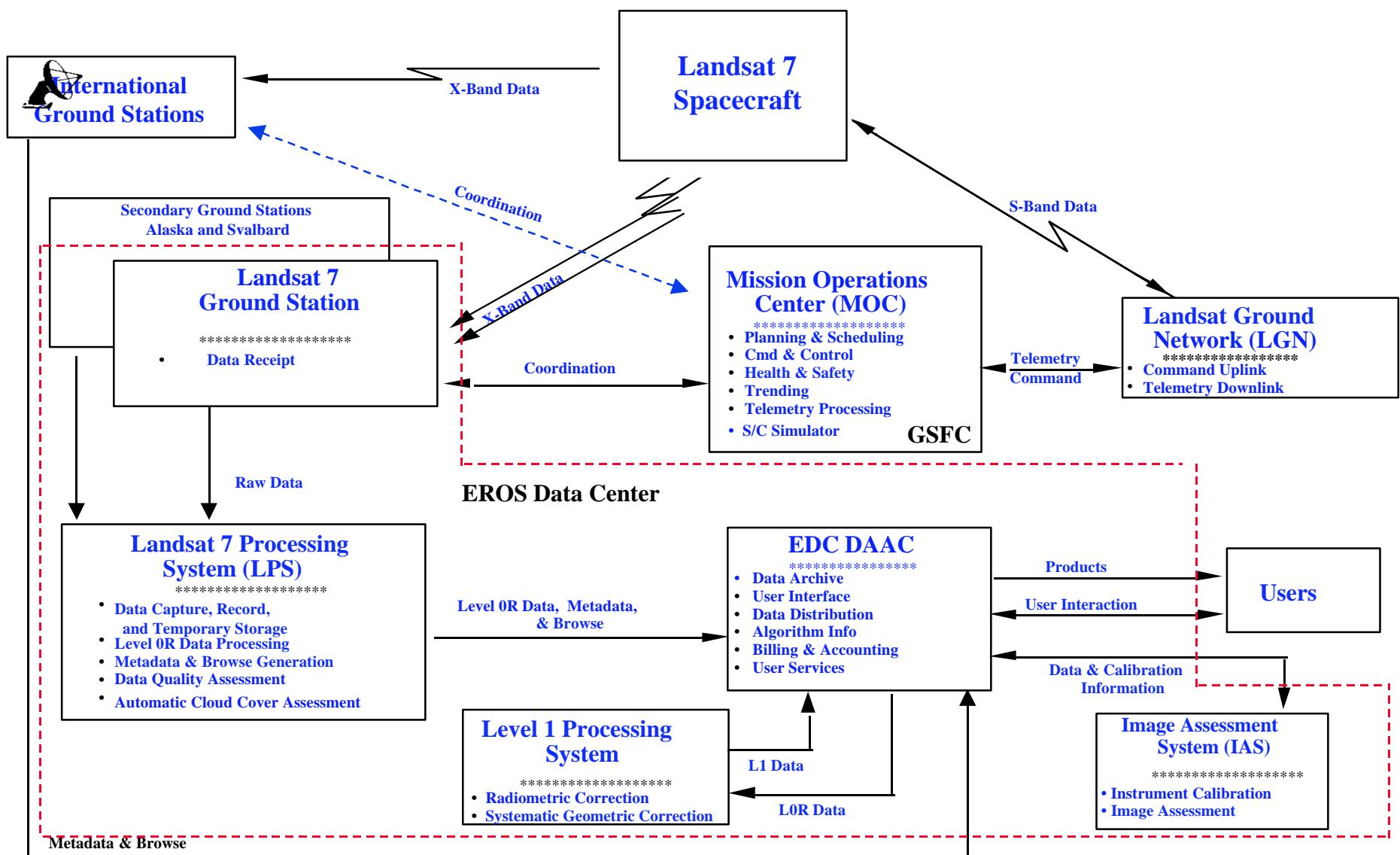
Landsat 7 Technical Session

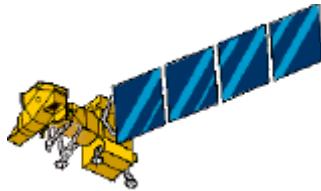
Landsat 7 Processing System (LPS)

Joy Henegar
NASA/GSFC

LPS Documentation Server: <http://lps-server.gsfc.nasa.gov>

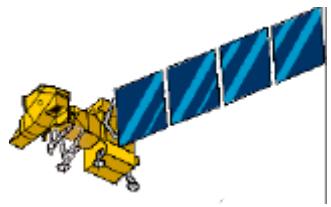
Landsat 7 Ground System



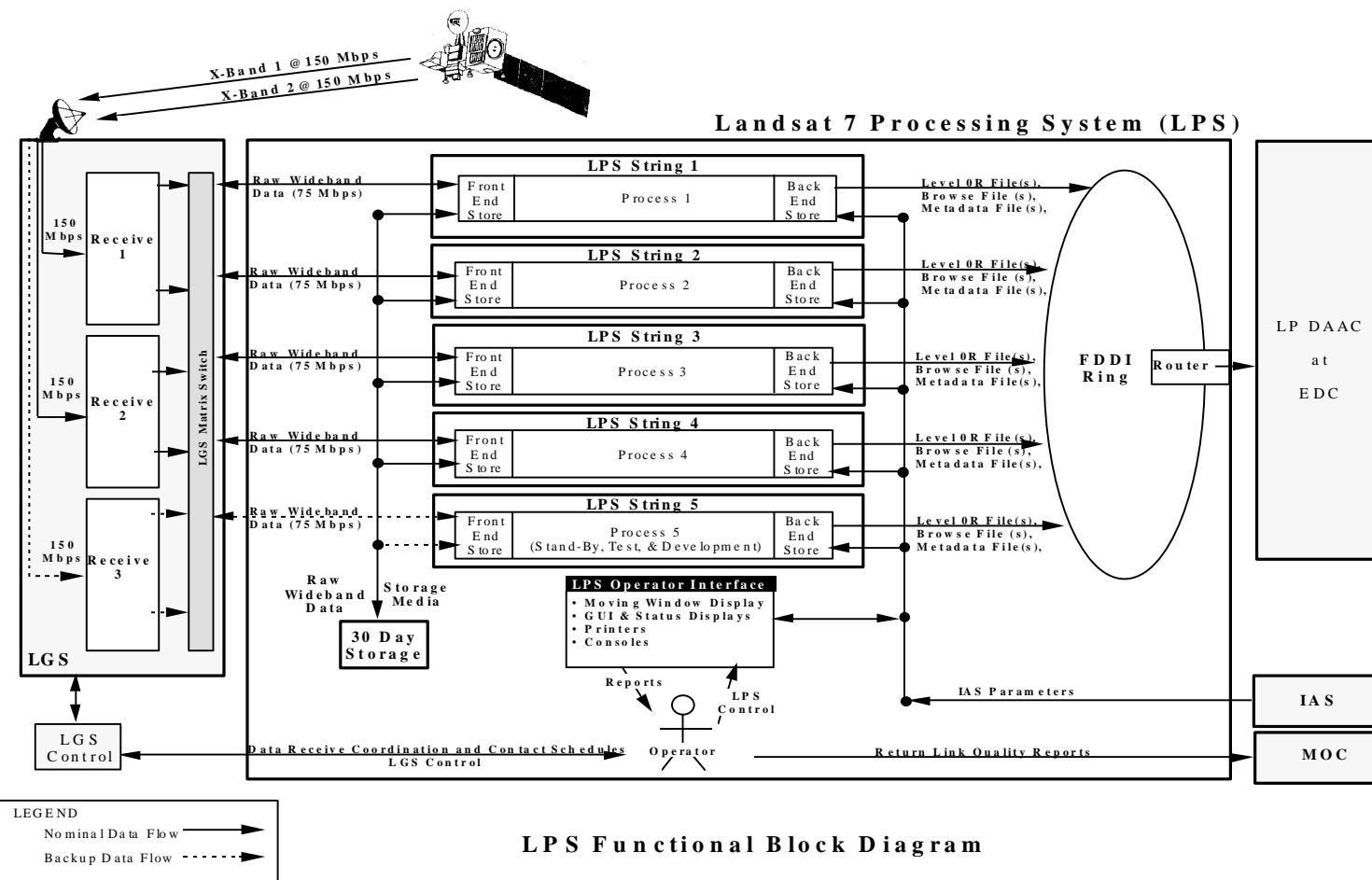


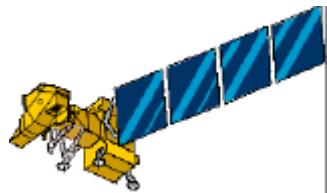
Agenda

- **Level 0R Processing Overview**
 - System Concept
 - Functional and Performance Requirements
 - Functional Processing Flow
 - LPS Output File Summary
 - LPS Architecture
 - LPS Software Availability

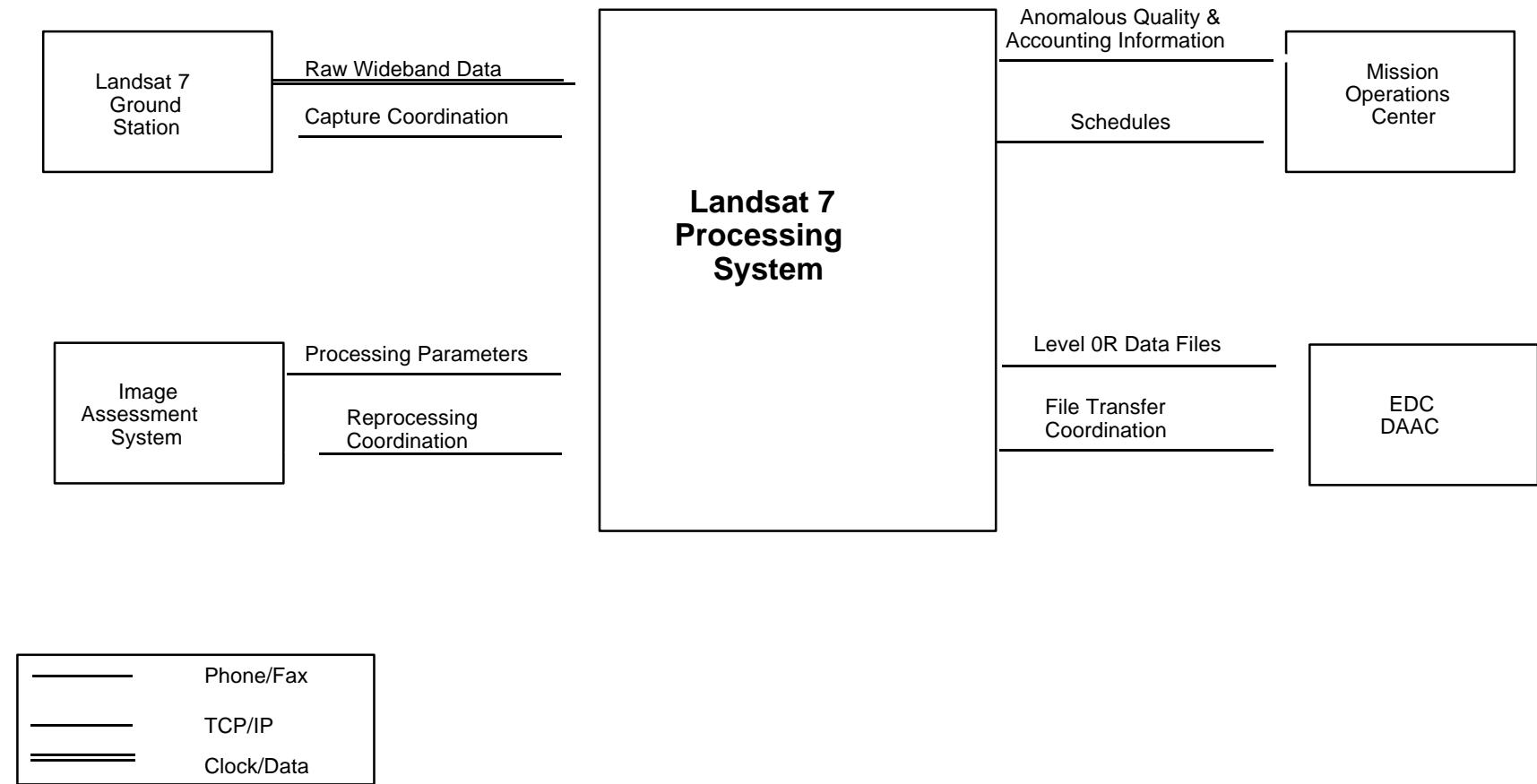


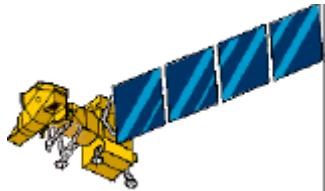
LPS Concept Diagram





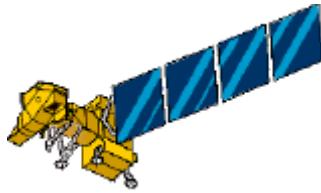
LPS Context Diagram





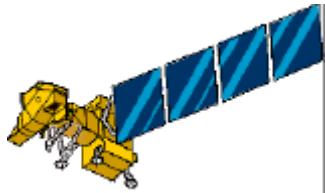
LPS Context Diagram (cont)

- **LGS**
 - Coordinate with the LGS to capture raw wideband data on contact basis
 - Receive raw wideband data at 75Mbps on four physical channels
- **MOC**
 - Receive Contact Schedules
 - Provide Return Link Quality and Accounting and Capture Summary information on an anomaly basis
- **IAS**
 - Receive processing parameters
 - Coordinate for reprocessing requests
- **EDC DAAC**
 - Notify EDC DAAC of data availability and make Level 0R files available for transfer
 - Receive Data Delivery Notice from the EDC DAAC



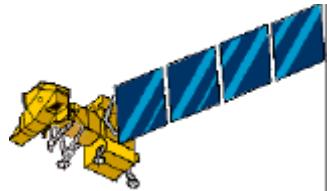
LPS Functional Requirements

- **Receive and record raw Landsat 7 wideband data from the LGS for 4 wideband data inputs simultaneously on a contact basis**
- **Perform CCSDS Grade 3 Service on all received wideband data**
 - CADU Frame Synchronization (including detection of inverted CADUs)
 - PN Decoding
 - Reed-Solomon EDAC on VCDU Header
 - Cyclic Redundancy Checking
- **Perform BCH Error Detection and Correction on all wideband data**
- **Generate Level 0R data files on a subinterval basis**
- **Generate Browse Data files on a scene basis**



LPS Functional Requirements (cont)

- Generate Metadata data files on a subinterval basis
- Provide return link quality and accounting as part of metadata
- Perform Automated Cloud Cover Assessment
- Identify WRS scene boundaries
- Coordinate the transfer of all Level 0R related data files to the EDC DAAC



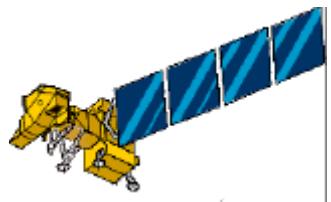
LPS Performance Requirements

- **Receive and process the equivalent of 250 ETM+ scenes per day**
- **Receive and record the raw wideband data at 75Mbps for each input data stream**
- **Process and notify the EDC DAAC of data availability within 16 hours of receipt of data**
- **Provide the capability to reprocess upto 10 percent of the wideband data on a daily basis**
- **Retain raw wideband data for a minimum of 30 days from time of receipt**
- **Sustain operations 24 hours a day, 7 days a week for a minimum mission life of 5 years**

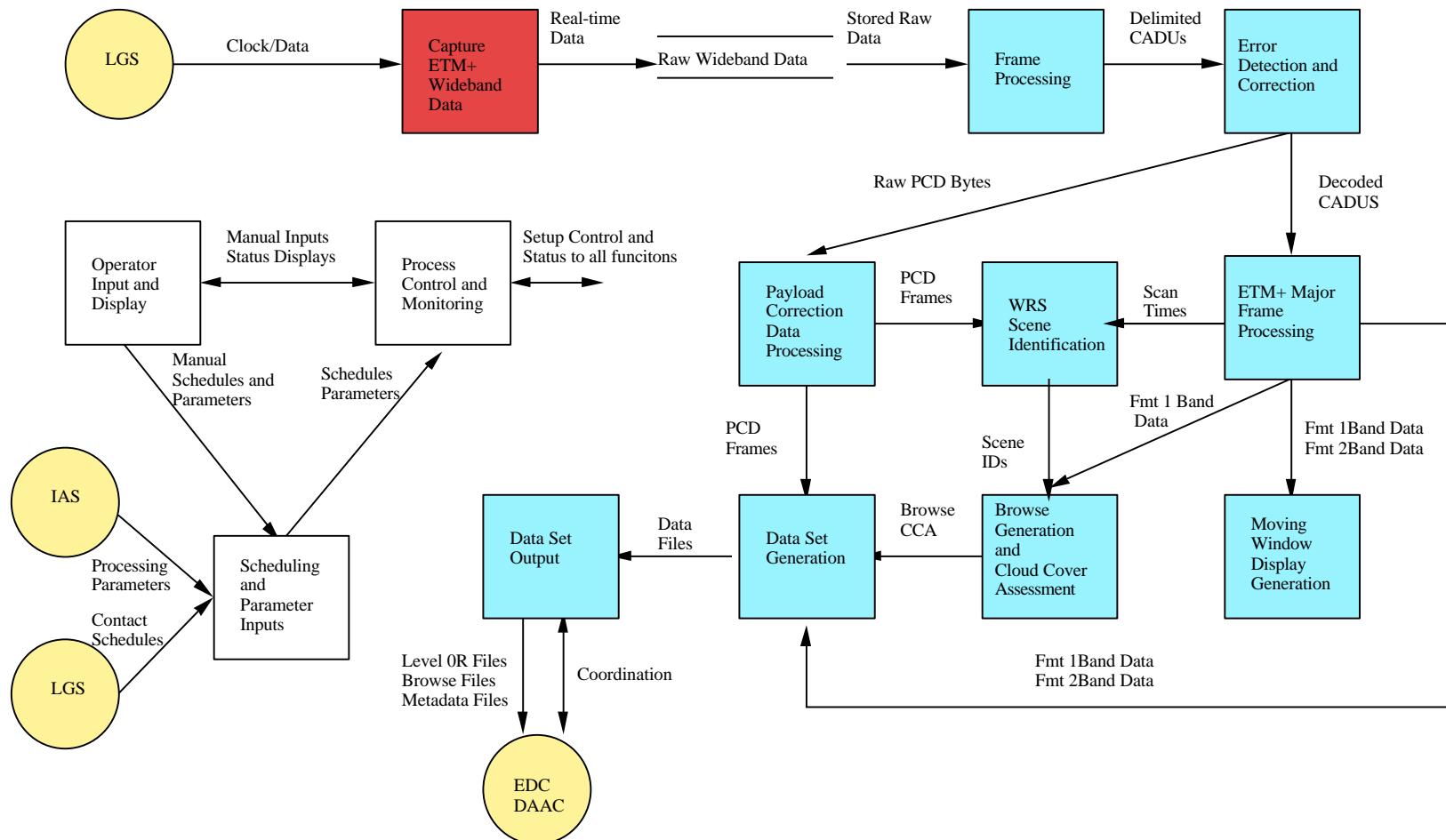


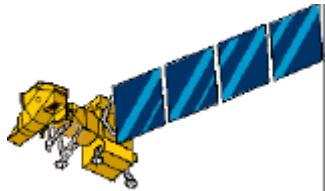
Definitions

- **Interval**
 - The time duration between the start and stop of an imaging operation (observation) of the Landsat 7 ETM+ instrument.
- **Subinterval**
 - A segment of a raw wideband data interval received during a Landsat 7 contact period. Subintervals are caused by breaks in the wideband data stream due to communication dropouts and/or the inability of the spacecraft to transmit a complete observation (interval) within a single Landsat 7 contact period.



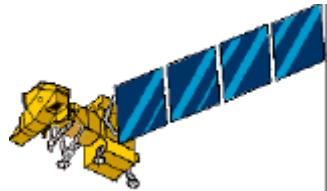
LPS Functional Requirements Flow





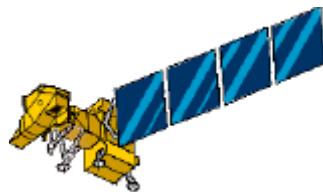
LPS Output Files (per string)

- **LPS Level 0R files**
 - **Instrument data files**
 - **Each file contains image data from single band in a single subinterval. Data nominally aligned using fixed and predetermined integer values**
 - **Calibration files**
 - **One file created per subinterval. Contains Calibration data received on a major frame basis**
 - **Mirror Scan Correction files**
 - **One file created per subinterval. Contains scan error and scan direction data**
 - **PCD (Payload Correction Data) files**
 - **One file created per subinterval. Contains Payload Correction Data for the subinterval**

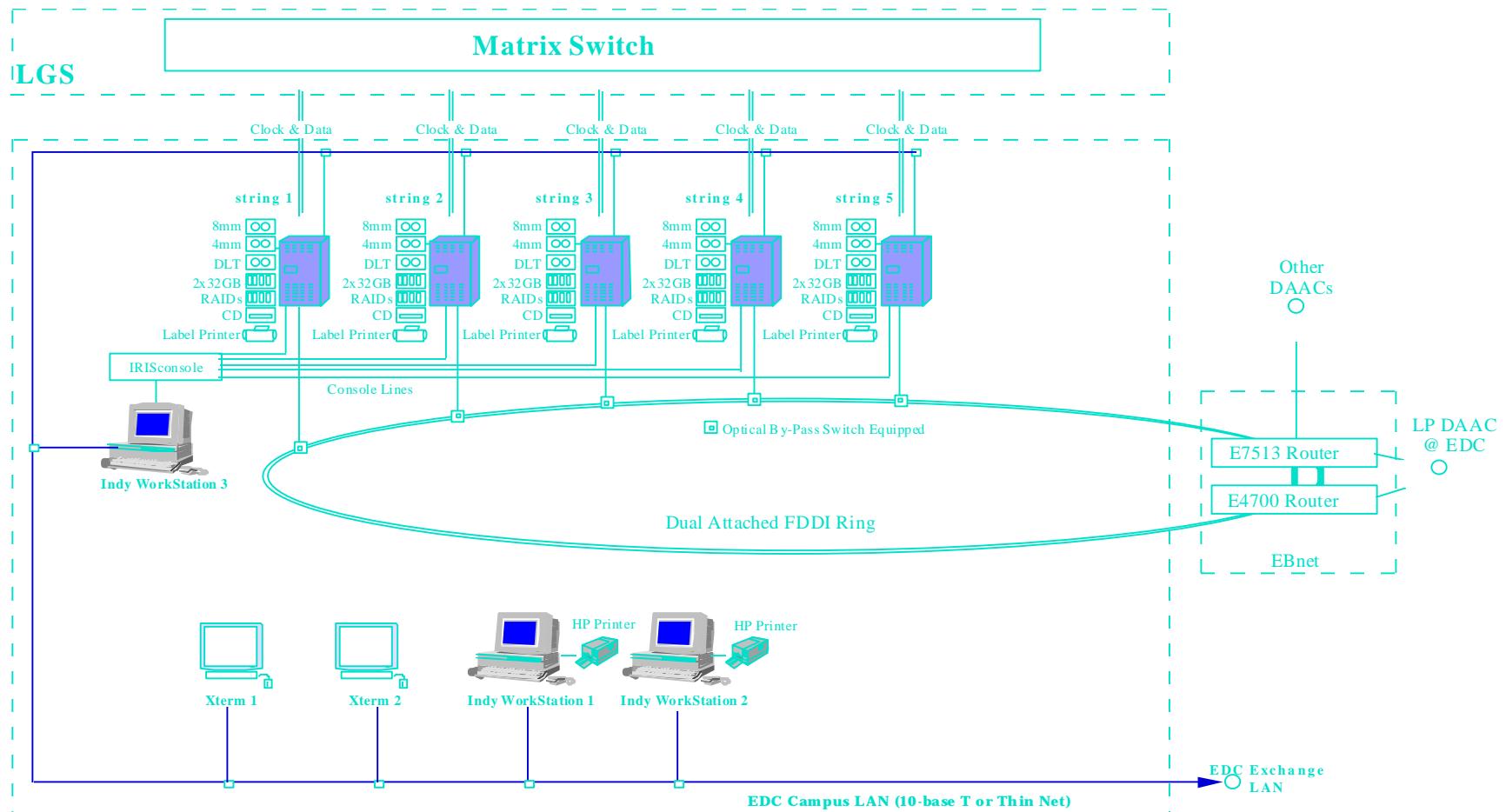


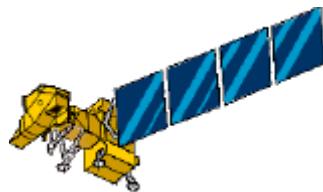
LPS Output Files (per string)

- **LPS Metadata file**
 - One file created per subinterval. Contains data quality and accounting information, cloud cover assessment, and scene identification information for the subinterval
 - **LPS Browse Image Files**
 - One multiband (image from three predefined bands) file created per scene. Contains reduced size scenes of the full size scene data contained in the Level 0R instrument data files.

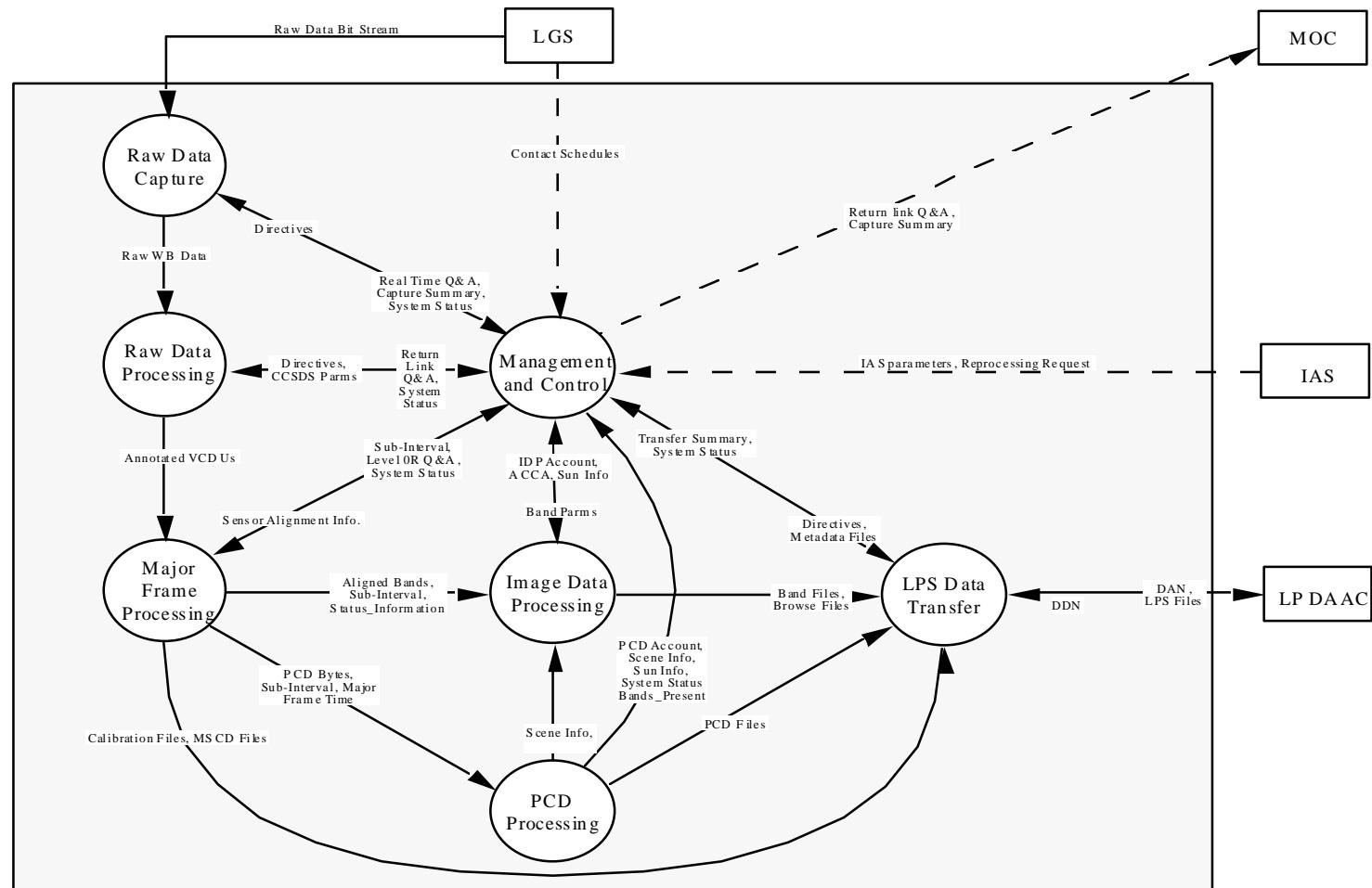


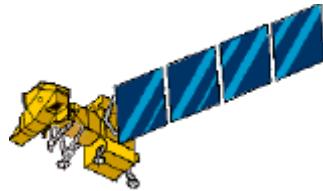
LPS Hardware Architecture





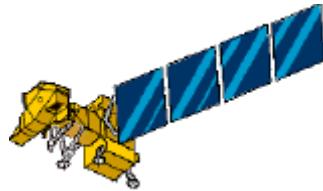
LPS System Architecture





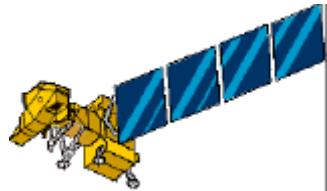
LPS System Architecture (cont)

- **Raw Data Capture Subsystem (RDCS)**
 - Receive and record raw wideband data from LGS
 - Manage LPS 30 Day archive
 - Generate raw data capture summary and tape labels
 - Playback raw raw wideband data for testing
- **Raw Data Processing Subsystem (RDPS)**
 - Perform CCSDS Grade 3 Service
 - Perform BCH Error Detection and Correction
 - Generate quality and accounting information
- **Major Frame Processing Subsystem (MFPS)**
 - Process ETM+ major frames
 - Extract Payload Correction Data bytes and status information
 - Generate Mirror Scan Correction Data files and Calibration files



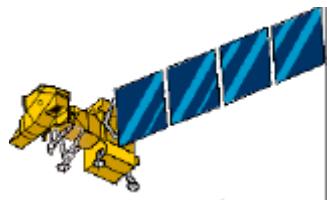
LPS System Architecture (cont)

- **Major Frame Processing Subsystem (MFPS) (cont)**
 - Determine Subintervals
 - Deinterleave/Reverse and Align Bands
 - Generate Level 0R quality and accounting information
- **Payload Correction Data Processing System(PCDS)**
 - Extract PCD Data
 - Determine Scene Identification
 - Produce PCD File
 - Produce PCD accounting information
- **Image Data Processing Subsystem (IDPS)**
 - Generate Browse Files and Band Files
 - Produce Automatic Cloud Cover Assessment
 - Produce browse, band and cloud cover accounting information
 - **Generate the Moving Window Display**

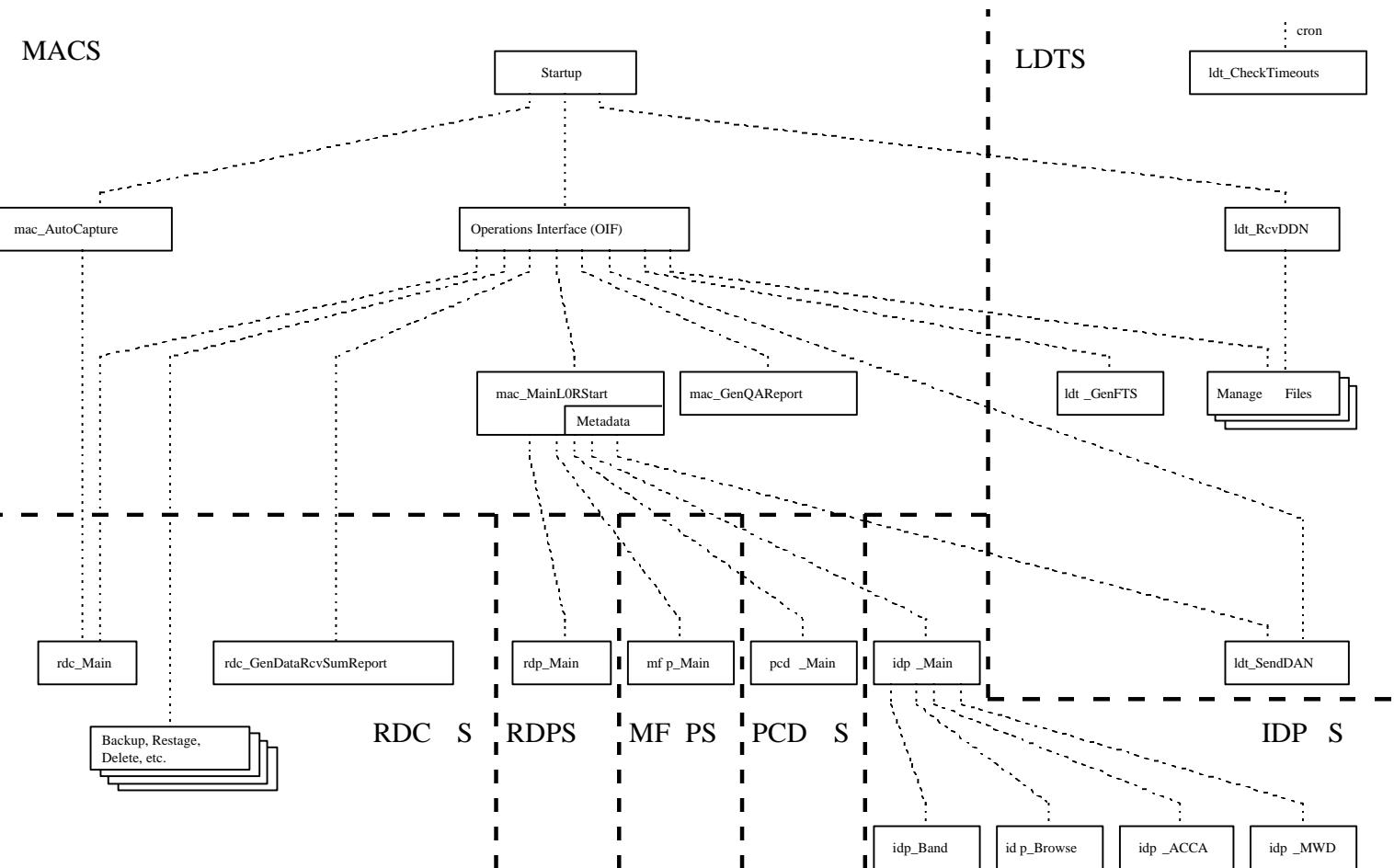


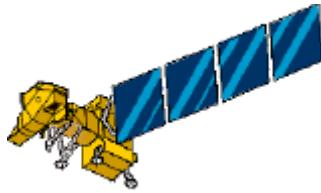
LPS System Architecture (cont)

- **Management and Control Subsystem (MACS)**
 - Control and Manage LPS top level process
 - Support LPS User Interface
 - Generate LPS metadata file
 - Generate LPS Level 0R Quality and Accounting Reports
 - Manage System start and shutdown
- **LPS Data Transfer Subsystem (LDTs)**
 - Coordinate LPS file transfer to the EDC DAAC
 - Provide network and communication support
 - Manages LPS output data store
 - Provide transfer summary information



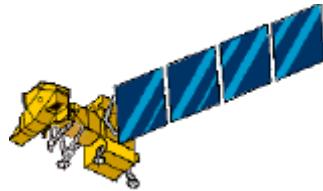
LPS Top Level Software Architecture





LPS Software Availability

- Current LPS Software has only been tested with simulated L7 Data and limited Landsat 5 converted to L7 data
- Software available through contacting the L7 Science Office
- LPS Release 2.1 Software
 - Items available include:
 - Source Code/Build Instructions
 - Test data files
 - List of Open Problems at time of delivery
- LPS Release 3.0 Software
 - Software delivered to EDC in 3/98 for Acceptance Testing and subsequent promotion to operations.
 - Software will be available through science office by 5/31/98
- Subsequent releases will be provided to address remaining open items and to address any problems found with receipt of data from Landsat 7 instrument and spacecraft testing



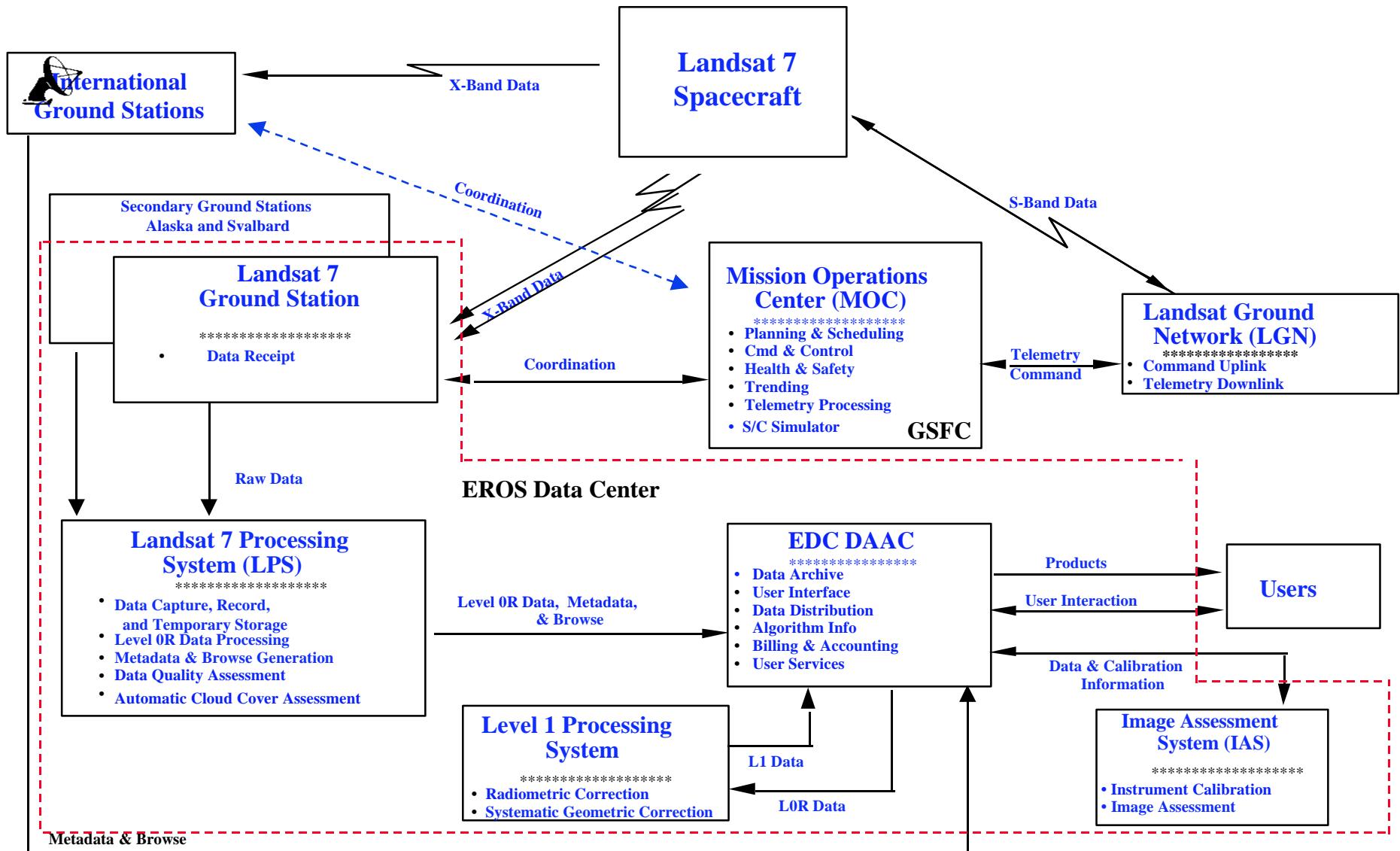
Landsat 7 Technical Session

Level 1 Product Generation System (LPGS)

Joy Henegar
NASA/GSFC

LPGS Documentation Server: <http://lpgs-server.gsfc.nasa.gov>

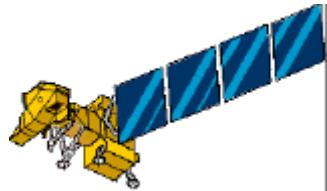
Landsat 7 Ground System





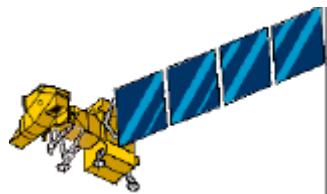
Agenda

- **Level 1 Processing Overview**
 - **System Overview and Concept**
 - **Functional and Performance Requirements**
 - **Processing Flow**
 - **LPGS Output File Summary**
 - **LPGS S/W Architecture**
 - **Algorithm development**
 - **Nominal Algorithm Flow**
 - **104khz Noise Correction Algorithm**
 - **IAS/LPGS Software Availability**

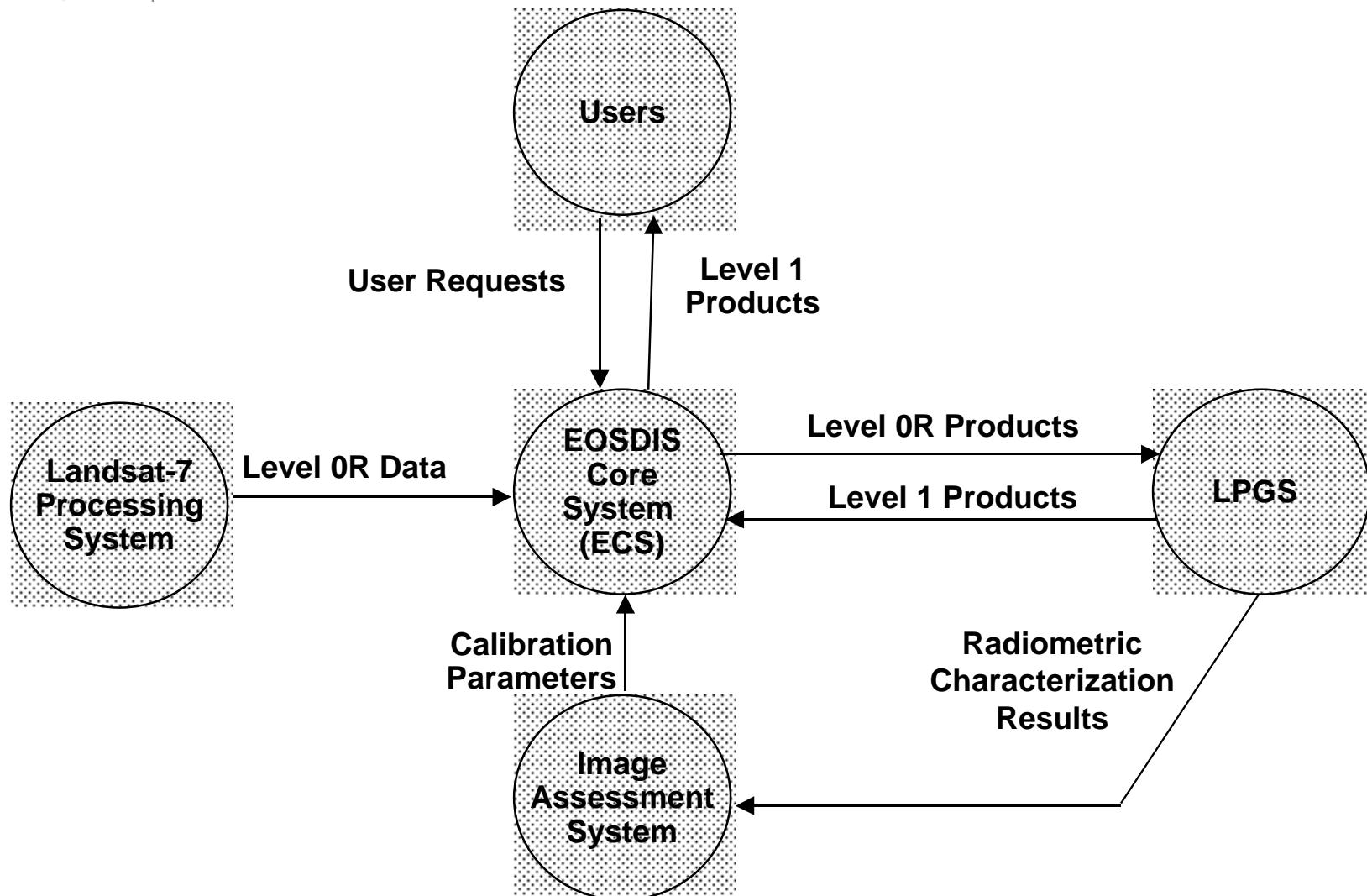


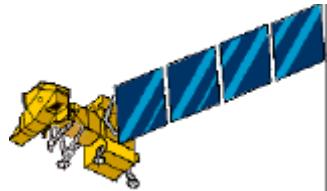
LPGS System Overview

- **LPGS is to provide the Landsat-7 user community with Level 1 digital products:**
 - **Level 1R (L1R)** - radiometrically corrected, but not geometrically resampled
 - **Level 1G (L1G)** - radiometrically corrected and resampled for geometric correction and geographic registration; DOES NOT INCLUDE precision or terrain correction
- **Users order and receive Level 1 products via the Earth Observing System Data and Information System (EOSDIS) Core System (ECS)**



LPGS System Concept

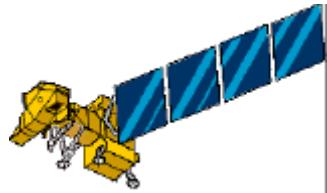




LPGS Functionality

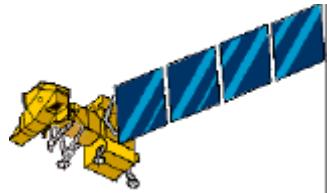
High Level Requirements

- Process a volume of data equivalent to 100 standard Level 0R world-wide reference system (WRS) scenes to Level 1 digital images per day
- Additional 10% reprocessing (110 total)
- Apply compensation for image artifacts
 - Banding, striping, coherent noise, memory effect, scan correlated shift, inoperable detectors, saturated detectors, and dropped scan lines



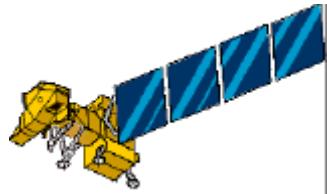
High Level Requirements (cont'd)

- **Support user-selectable processing options (details later):**
 - Product selection, map projection, orientation, grid cell size, output product format, band(s) selection, resampling filter, calibration processing
- **Generate Level 1 digital images corresponding to either**
 - Heritage WRS scene
 - Partial ETM+ subinterval
 - Covering any contiguous portion of a subinterval between .5 to 3 WRS scenes



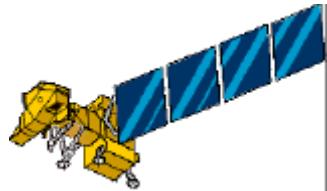
High Level Requirements (cont'd)

- **Provide quality assessment and visual display of Level 1 products**
- **Provide off-line analysis of image processing problems**
- **Interface with ECS to:**
 - Receive Level 1 product requests and L0R products
 - Deliver Level 1 products
- **Interface with the Image Assessment System (IAS) to transfer radiometric characterization results**



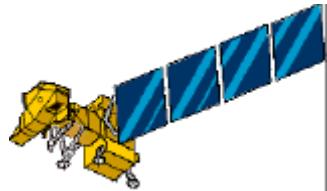
User-Selectable Parameters

- **Product selection**
 - L1R
 - L1G
- **Coordinate reference system for map projection**
(and projection-specific parameters)
 - Space Oblique Mercator
 - Universal Transverse Mercator
 - Lambert Conformal Conic
 - Transverse Mercator
 - Oblique Mercator
 - Polyconic
 - Polar Stereographic



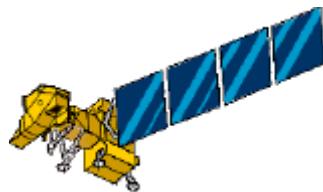
User-Selectable Parameters (cont'd)

- **Orientation**
 - Nominal path
 - North-up
- **Grid cell size**
 - Variable from 15 to 60 meters at .001 meter increment
- **Output product format**
 - HDF (L1R or L1G)
 - FAST- L7A (L1G only)
 - GeoTIFF (L1G only)

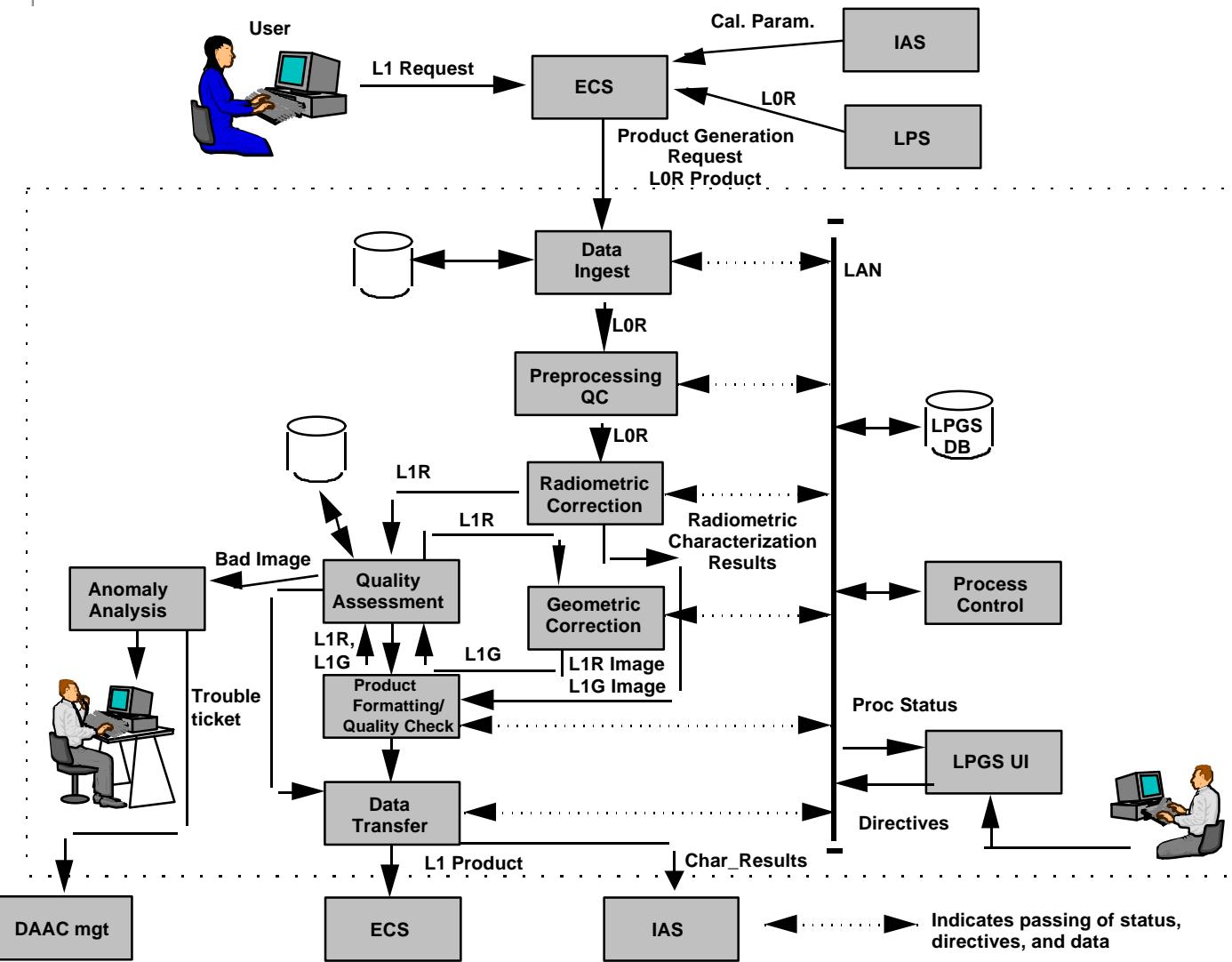


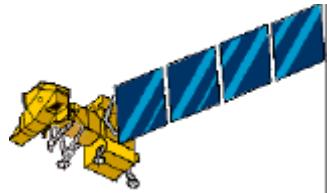
User-Selectable Parameters (cont'd)

- **Selected band(s)**
 - All 8 or a subset
- **Resampling filter**
 - Nearest neighbor
 - Cubic convolution
 - Modulation transfer function
- **Calibration processing**
 - Calibration parameter file
 - Internal calibrator



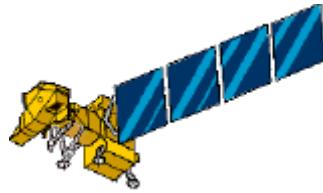
LPGS Processing Flow





Level 1 Product Formats

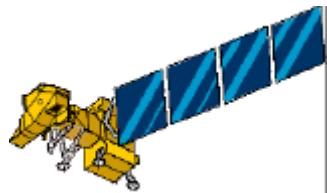
- Output products fully described in the *Earth Science Data and Information System (ESDIS) Level 1 Product Generation System (LPGS) Output Files Data Format Control Book (DFCB)*, April 1998 (accessible via LPGS documentation server)
- Level 1 output product formats
 - L1R
 - HDF
 - L1G
 - HDF
 - FAST- L7A
 - GeoTIFF



Level 1 Product Formats (cont'd)

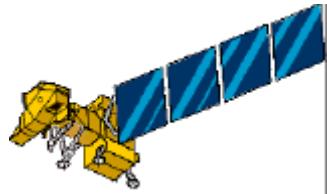
- **L1R - HDF**

- **Image data** (each file contains one band of image pixels in 16-bit unsigned integers)
- **Consensus MSCD** (subsetted according to product ordered)
- **Consensus PCD**
- **Calibration parameter file**
- **Internal calibrator data**
 - Format 1 for products that include bands 1 through 6 low
 - Format 2 for products that include bands 6 high through 8
 - Subsetted according to the product ordered
- **Geolocation index**
- **Scan line offsets** (subsetted according to the product ordered)
 - Format 1 for products that include bands 1 through 6 low
 - Format 2 for products that include bands 6 high through 8
- **LPS metadata (Format 1 and Format 2)**
- **LPGS metadata**



Level 1 Product Formats (cont'd)

- **L1G - HDF**
 - **Image data (each file contains one band of image pixels in 8-bit unsigned integers)**
 - **LPGS metadata**
- **L1G - FAST L7A**
 - **Header file**
 - **Administrative record contains information identifying product, image, and data needed to ingest image data**
 - **Radiometric record contains coefficients needed to convert image digital values into at-satellite spectral radiance**
 - **Geometric record contains image geodetic location information needed to align imagery to other data sources**
 - **Image data (each file contains one band of image pixels in 8-bit unsigned integers)**



Level 1 Product Formats (cont'd)

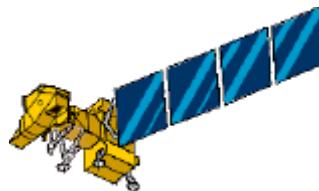
- **L1G - GeoTIFF**

- Image data (each file contains one band of image pixels in 8-bit unsigned integers)
- GeoTIFF products cannot be ordered in Space Oblique Mercator or Oblique Mercator Type A projections

- **LPGS Metadata**

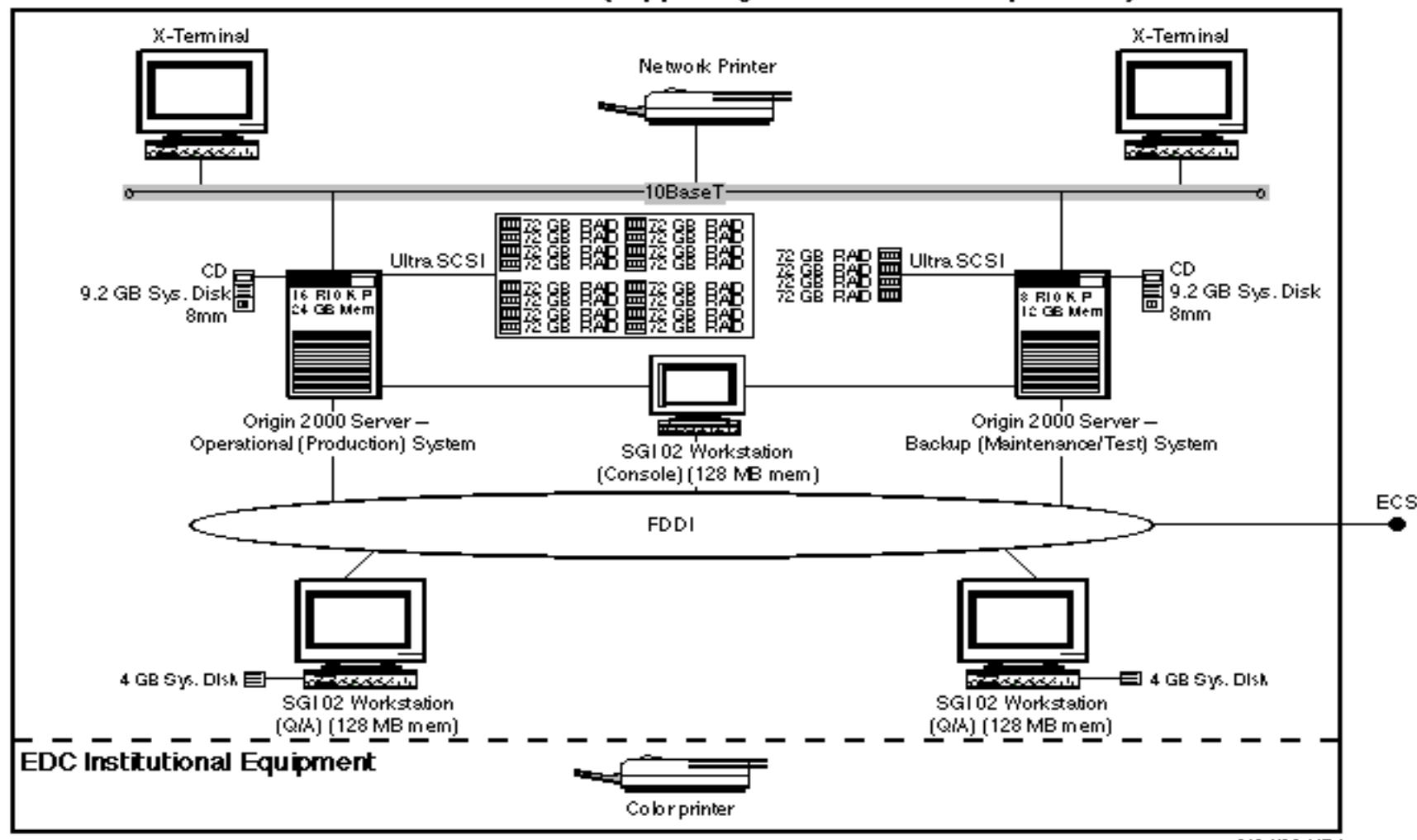
- Included with HDF L1R and L1G products
- Contains
 - HDF directory
 - Filenames
 - Band combination
 - Product path and row
 - Product corners
 - Gains
 - Corrections applied
 - Minimum and maximum detected radiance
 - Datum*
 - Ellipsoid *
 - Grid cell size *
 - Orientation *
 - Resampling method*
 - Map projection*
 - Projection parameters*

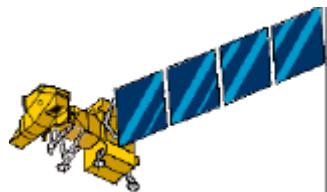
*L1G product only



LPGS Hardware Architecture

LPGS Hardware Architecture (Supporting 100 WRS Scene Requirement)

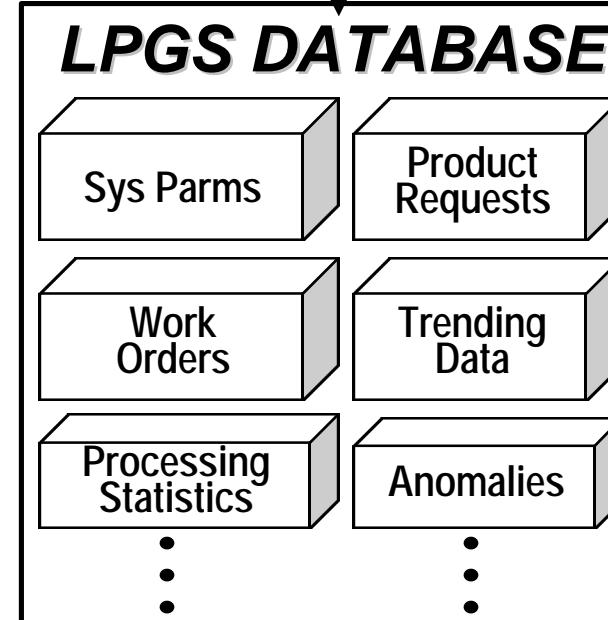




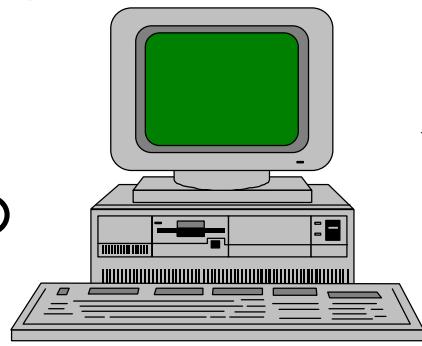
Software Architecture

LEGEND

- Oracle Pipe
- COTS IF
- ↔ Database Access
- ↔ Script parms/status



User Interface

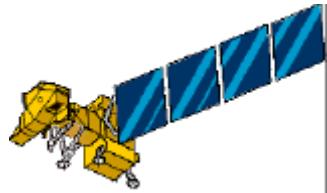


BACKGROUND TASKS

SCRIPTS

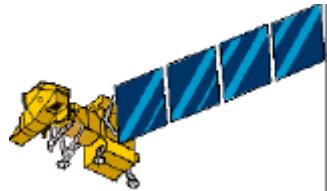
COTS

OPERATING SYSTEM



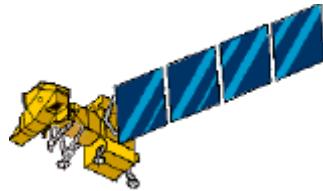
LPGS Subsystem Overview (1 of 3)

- **Data Management Subsystem (DMS)**
 - Handles communication with external interfaces
 - Ingests L0R product
 - Distributes L1 product
 - Performs preprocessing of L0R product
 - Formats and packages final L1 product
 - Monitors and manages LPGS disk space
- **Process Control Subsystem (PCS)**
 - Schedules production processing
 - Sets up, monitors, and controls production processing



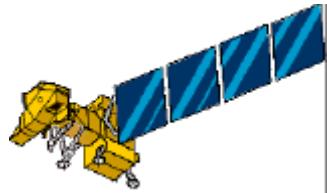
LPGS Subsystem Overview (2 of 3)

- **Radiometric Processing Subsystem (RPS)**
 - Performs radiometric characterization and correction
 - Reused from IAS
- **Geometric Processing Subsystem (GPS)**
 - Creates systematically corrected L1G imagery
 - Reused from IAS



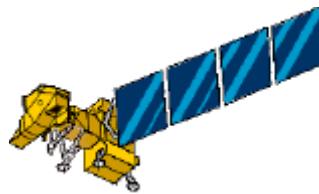
LPGS Subsystem Overview (3 of 3)

- **Quality Assessment Subsystem (QAS)**
 - Generates and assembles post production quality information
 - Produces summary of processed image quality
 - Provides tools for visual inspection of images
- **Anomaly Analysis Subsystem (AAS)**
 - Analyzes L1 images and associated information to resolve production anomalies
 - Provides tools for investigating problems encountered during processing or problems reported in trouble tickets
 - Provides results of trouble ticket analysis to ECS
 - Sends unresolved problems to ECS for further investigation

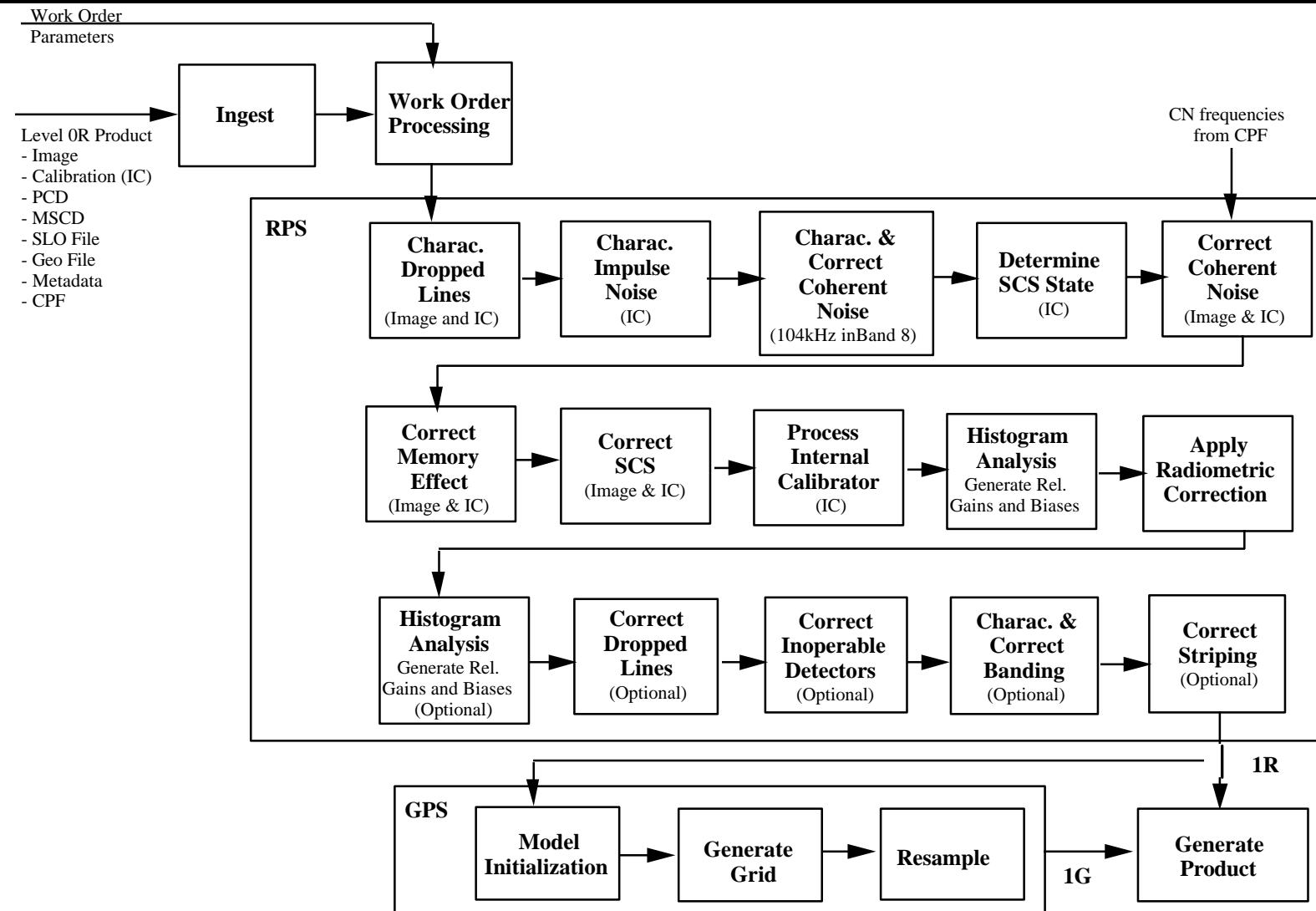


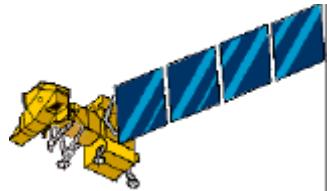
Algorithm Development Approach

- All algorithms used in the LPGS are being developed by the Landsat 7 Image Assessment System
- Algorithms required for production processing are pulled from the IAS configured software and are integrated into the LPGS Software without modification

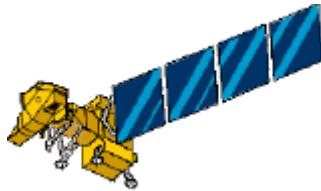


LPGS Operational Flow



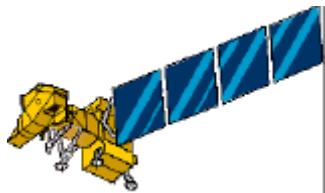


104khz Noise Algorithm



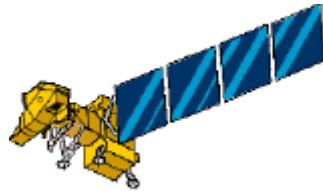
IAS/LPGS Software Availability

- Current software has only been tested with simulated L7 Data and limited Landsat 5 converted to L7 data
 - Software available through contacting the L7 Science Office
 - IAS Release 2 Software currently available
 - Items available include:
 - Radiometry and Geometry Algorithms
 - Source Code/Build Instructions
 - Test data files
 - List of Open Problems at time of delivery
 - IAS Release 3.0 Software
 - Software will be delivered to EDC in 6/98 for Acceptance Testing and subsequent promotion to operations.
 - Software will be available through science office by 7/31/98
 - Subsequent releases will be provided to address remaining open items and problems found with test data from L7 instrument and spacecraft testing
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LPGS Software Availability

- **LPGS Release 1.0 Software will be available by 6/98**
 - Items to be made available include:
 - Source Code/Build Instructions
 - Test data files
 - List of Open Problems at time of delivery
 - **LPGS Release 2.0 Software**
 - Software will be delivered to EDC for Acceptance Testing and subsequent promotion to operations in 10/98.
 - Software will be available through science office by 12/31/98
 - This release will meet all currently baselined LPGS Requirements
 - **LPGS Release 3.0 Software**
 - Release will address impending new requirements and incorporation of latest version of algorithms from subsequent IAS releases
 - Software will be delivered to EDC for Acceptance Testing and subsequent promotion to operations by 1/31/99.
 - **Software will be available by 3/1/99**
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Acronyms

DFCB	Data Format Control Book
ECS	EOSDIS Core System
EDC	EROS Data Center
EOS	Earth Observing System
EOSDIS	EOS Data and Information System
EROS	Earth Resources Observation System
GSFC	Goddard Space Flight Center
HDF	Hierarchichal Data Format
IAS	Image Assessment System
L0R	Level 0R
L1G	Level 1G (geometric)
L1R	Level 1R (radiometric)
LPGS	Level 1 Product Generation System
LPS	Landsat-7 Processing System
MSCD	Mirror Scan Correction Data
NASA	National Aeronautics and Space Administration
PCD	Payload Correction Data
WRS	World-wide Reference System